

## **Utilization of reserve capacities in electricity markets to mitigate price spikes:** Impact on national and surrounding bidding zones

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# Agenda

- Motivation
- Electricity market model
  - Timeline of decisions
  - Utilizing reserve capacity at a specific strike price
- Case study
  - Scenarios
  - Dataset
  - Results
- Discussion and Conclusion

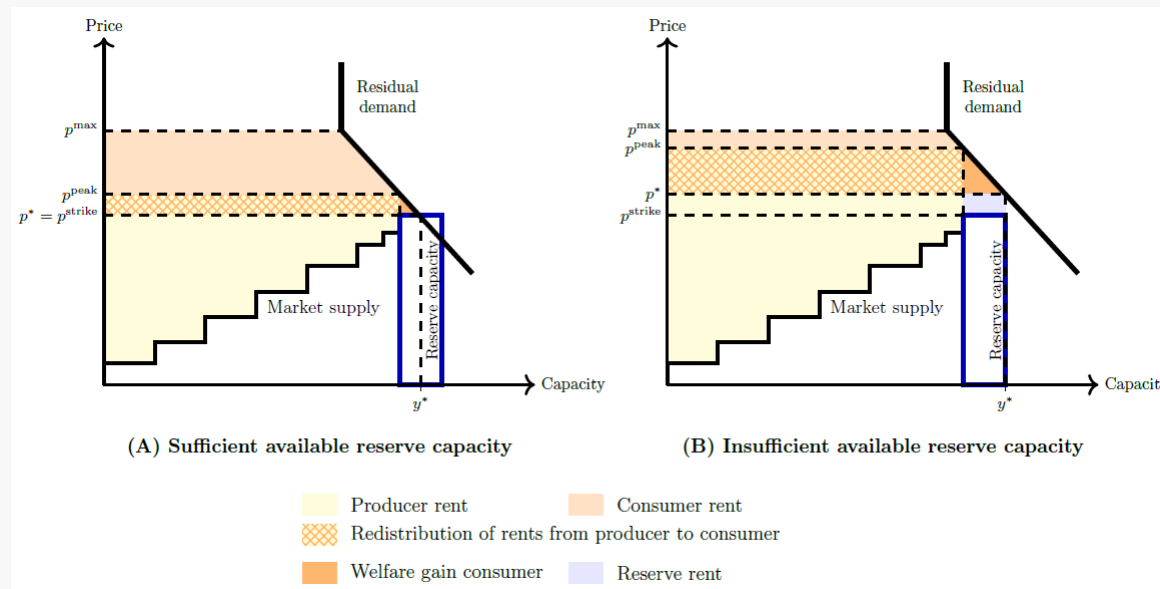
# Motivation: Provision of reserve capacity outside the electricity market

Reserve capacities in Germany

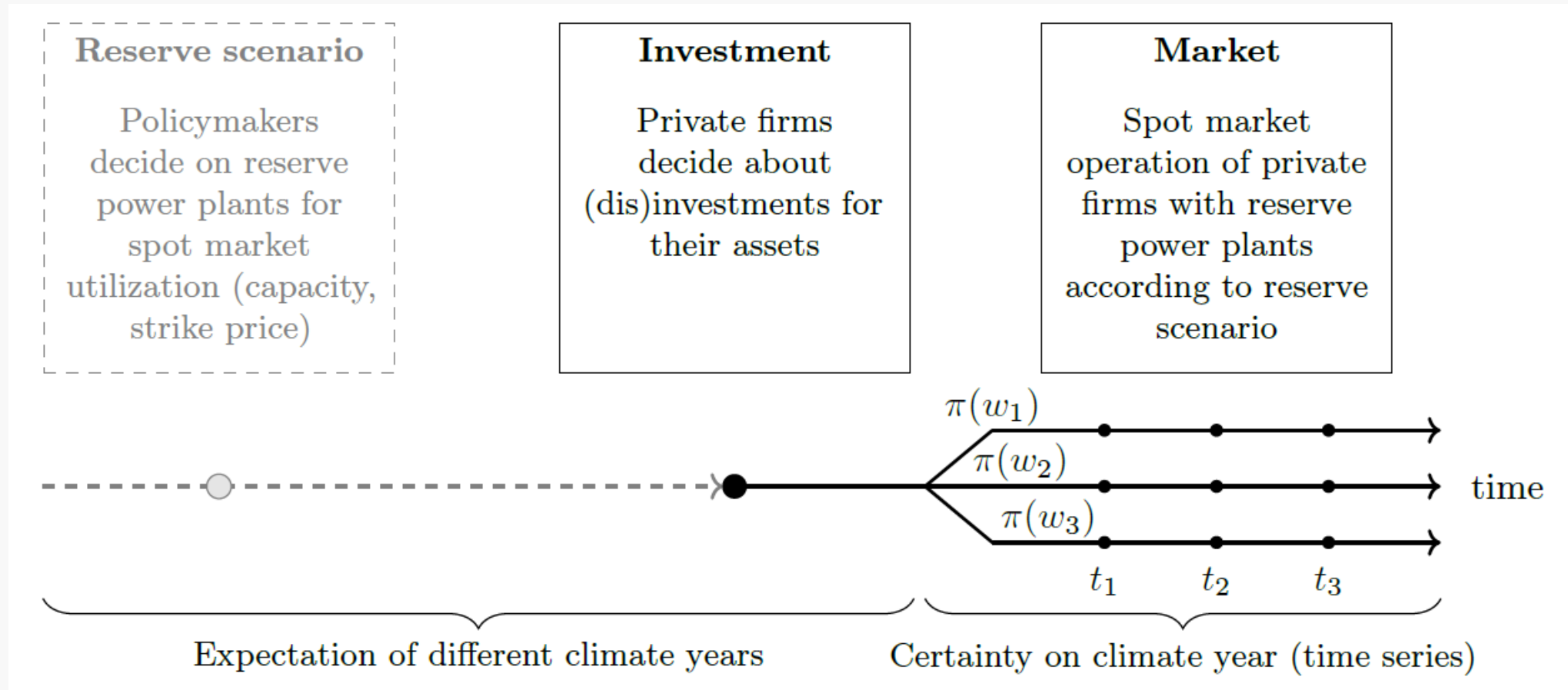
	Capacity [GW]	Provision cost [Mio. EUR]	Quantities [GWh]	Production cost [Mio. EUR]
<b>Capacity reserve</b>	1.4	91	-	-
<b>Grid reserve</b>	8.6	694	1 787	357

Sources: Bundesnetzagentur (2025), Bundesnetzagentur and Bundeskartellamt (2025), and Smard (2025)

**Utilization of reserve power plants in the electricity market to reduce prices during periods of scarcity**



## Modeling approach: Considering timeline of decisions



# Modeling approach: Electricity market model

*Max* Expected spot market welfare of the system

*subject to*

- Zonal electricity balance (Kirchhoff's first law)
- Generation constraints of power plants (existing and invested)
- Capacity constraints (for disinvestment)
- *Available reserve capacity for electricity generation at a strike price*
- Storage operation
- Electrolysis constraint
- Inter-zonal trade constraints (NTC)

## Results

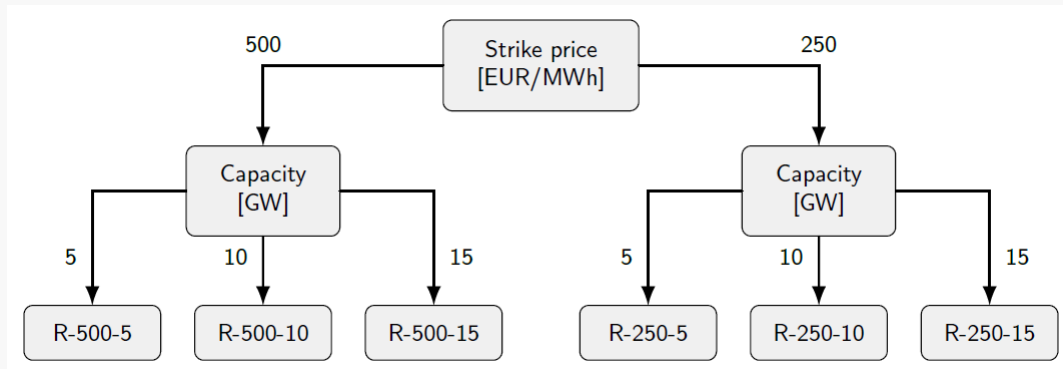
- **Zonal electricity prices**
- Generation quantities
- **Utilization of reserve capacity**
- Zonal electricity demand
- **Decommissioning of fossil generation capacities**
- **Investment in generation capacity, battery and electrolysis**

# Case Study:

Analyzing **national** and **international effects** of **utilizing reserve capacities** at a specific **strike price** in the **German bidding zone** on **electricity prices**, **(dis)investment** decisions and **rents**

## Case Study: Scenarios and Data

### Scenarios



### Aggregated European data set

- **Target year 2030**
- Main source: TYNDP 2024/2022, status quo data
- Zonal representation of Germany and its neighboring countries, incl. GB, UKNI, IE, NO, SE and IT, ES and PT
- Three climate years (1995, 2008, 2009) with probabilities (0.23,0.37,0.40)
  - Generation time series of fluctuating RES (solar, wind)
  - Demand time series
- Zonal demand and generation time series
- Exogenous: solar, wind on-/offshore, biofuels, hydro and nuclear
- Endogenous (dis)investments in fossil generation capacities, batteries and electrolysis

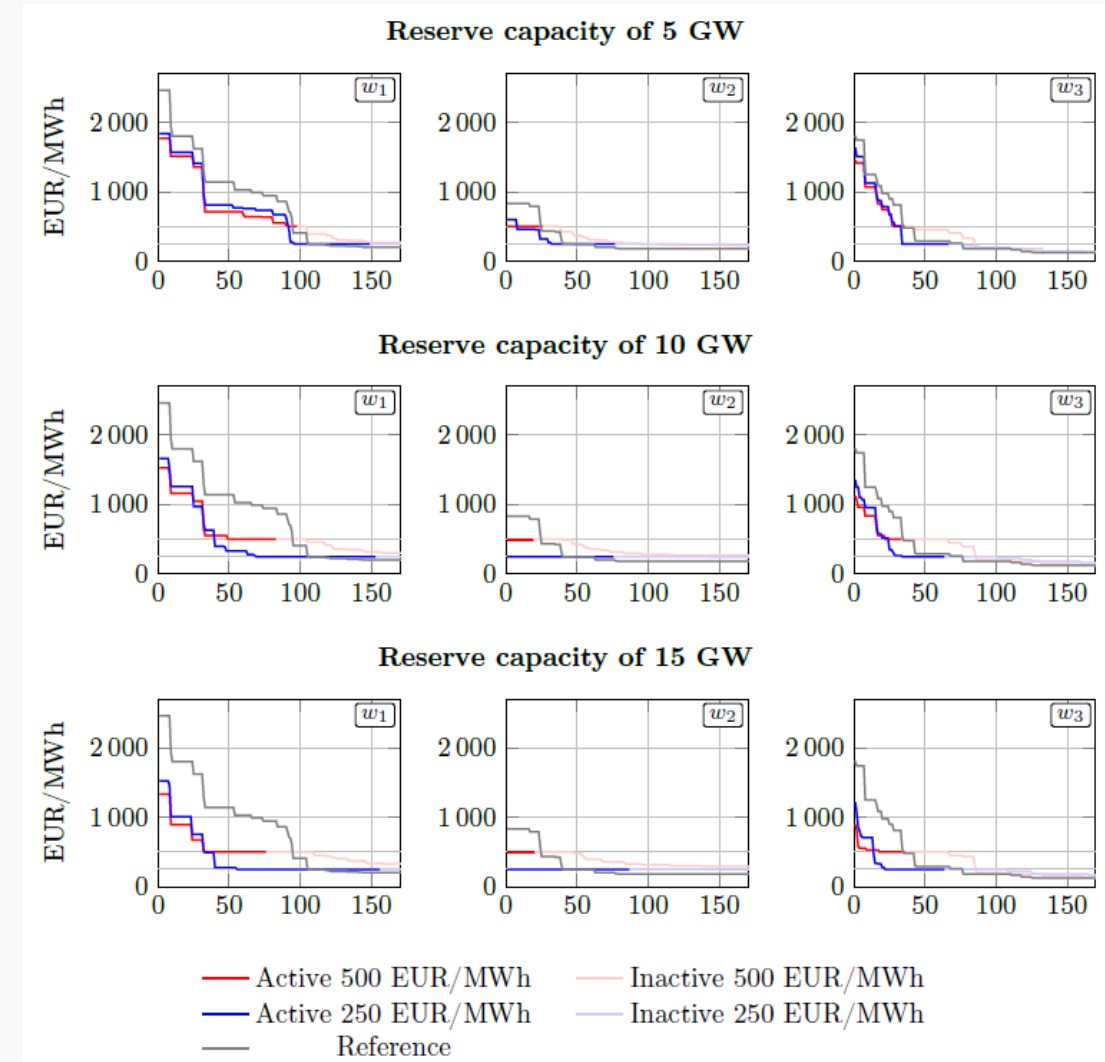
## Result: Price effects

### Utilization of reserve capacity: market price $\geq$ strike price

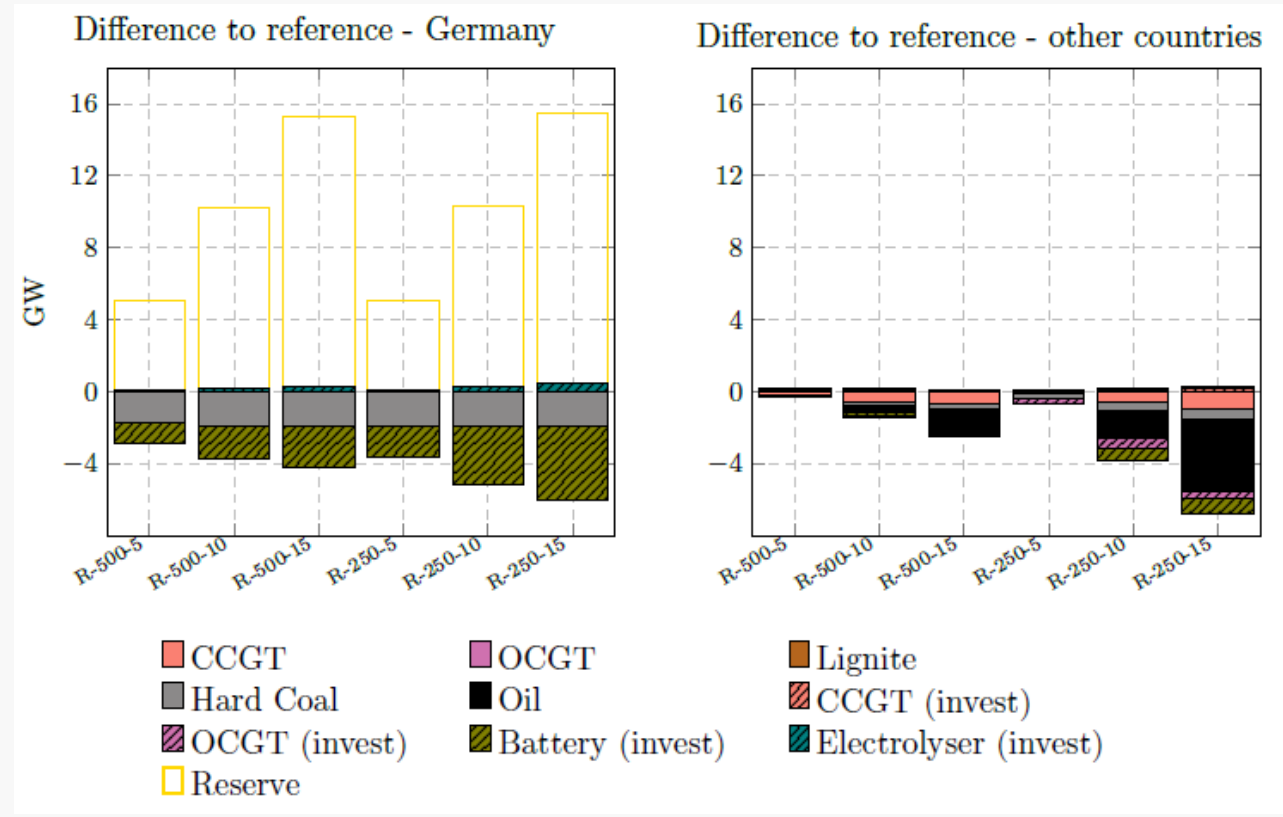
- Price reduction in hours with active reserve generation
- (Reduced) scarcity prices in most reserve scenarios and climate years
- **Intersection point of price duration curves:** price level of the reference scenario lower than price level of the reserve scenario
  - Price increase in other hours (non-peak price hours)
  - Dynamic effects on (dis)investment decisions in generation capacity
- Effects on the annual demand-weighted average spot market price vary, depending on reserve scenario and climate year

### Similar price effects in other countries

- More pronounced effects in countries with
  - higher price levels and
  - direct trading links to Germany



# Result: (Dis)investment effects



## Germany

- Market-driven hard coal phase-out (~1.8 GW)
- Reduction of investments in batteries:  
high strike price: (~1.2 – 2.3 GW)  
low strike price: (~1.7 – 4.1 GW)

## Other countries

- 15 GW reserve capacity utilization induces decommissioning of up to 5.8 GW
  - Oil-peakers mainly in FR
  - Hard coal in PL
  - Batteries in NL and AT
  - Gas in DK, CZ and ES

# Result: Distributional effects (without considering rents of reserve capacities)

## Germany

[Mio. EUR]	R-500-5	R-500-10	R-500-15	R-250-5	R-250-10	R-250-15
CS	-75.2	-91.6	-50.0	160.3	1 059.8	1 436.4
CR	14.0	36.3	51.3	-5.0	-80.8	-102.4
PR	83.6	108.5	88.5	-67.2	-631.3	-873.9
Conv	5.0	-0.3	-10.6	-71.8	-345.7	-460.9
RES	109.6	156.3	161.9	62.8	-144.3	-236.8
STO	-31.0	-47.6	-62.7	-58.3	-141.3	-176.2
<b>Total effect</b>	<b>22.4</b>	<b>53.2</b>	<b>89.7</b>	<b>88.2</b>	<b>347.6</b>	<b>460.1</b>

- Positive effects on total rents
- Consumer benefit from a low strike price
- Renewable energy sources benefit from a high strike price
- Conventional generators and storage loose in rents

## Other countries

[Mio. EUR]	R-500-5	R-500-10	R-500-15	R-250-5	R-250-10	R-250-15
CS	118.7	370.1	414.6	163.8	798.3	993.9
CR	6.9	14.8	31.3	-25.2	-189.8	-222.2
PR	-115.1	-354.0	-398.4	-190.5	-819.4	-1 029.2
Conv	-98.7	-260.5	-292.1	-122.0	-500.0	-623.9
RES	27.2	12.1	15.4	-4.9	-121.9	-158.9
STO	-43.5	-105.6	-121.7	-63.6	-197.6	-246.4
<b>Total effect</b>	<b>10.5</b>	<b>30.8</b>	<b>47.6</b>	<b>-52.0</b>	<b>-211.0</b>	<b>-257.5</b>

- Consumer benefit from German reserve utilization
- Producer in other countries loose
- Low strike price: total effect on welfare is negative

## Discussion: Reserve utilization

**Revenues [Mio. EUR], production quantities [GWh] and cost estimation [Mio. EUR] of reserve capacities combined for all climate years**

	R-500-5	R-500-10	R-500-15	R-250-5	R-250-10	R-250-15
Reserve revenues	187.2	253.4	271.5	243.7	325.0	370.7
Reserve generation	221.9	345.2	430.5	403.1	705.1	911.0
Cost estimation of reserve utilization						
Operating cost	44.3	69.0	86.0	80.5	140.9	182.0
Capacity provision cost	392.5	785.0	1 177.5	392.5	785.0	1 177.5

Cost estimation based on Bundesnetzagentur (2025), Bundesnetzagentur and Bundeskartellamt (2025), and Smard (2025)

### Trade-off between potential system cost reduction and loss of security of supply

- **Earned revenues** of reserve capacities can **cover operation cost** and **to some extent capacity provision cost**
  - potential **cost reduction effect** on network cost and therefore system cost
- **Reduced availability** of reserve capacity as backup **to ensure security of supply**
  - potential **negative effect on system cost**, leading to an **increase in costs**

## Conclusion

- I) **Utilization of reserve power plants** in the electricity market can **reduce prices during (few) peak prices hours**
- II) In all **other hours, prices** may **rise** due to **dynamic effects on (dis)investment** decisions of market agents
  - Market-driven reduction of dispatchable generation capacity
  - Reduced incentives to invest in storage options
- III) **Effects** can also be observed in **other European countries**
- IV) **Trade-Off** between **potential system cost reduction** and **loss of security of supply**
- V) **Unilateral national interventions** in the electricity market must be **carefully evaluated** in context with the European internal market for electricity

# Sources

## Motivation:

CDU, CSU, and SPD (2025). Verantwortung für Deutschland: Koalitionsvertrag zwischen CDU, CSU und SPD. 21. Legislaturperiode. url: [https://www.koalitionsvertrag2025.de/sites/www.koalitionsvertrag2025.de/files/koav\\_2025.pdf](https://www.koalitionsvertrag2025.de/sites/www.koalitionsvertrag2025.de/files/koav_2025.pdf).

Czock, B. H., J. Junkermann, and L. Just (2025). Back (-up) for good? Implikationen einer Rückkehr von Reservekraftwerken an den Strommarkt. EWI Policy Brief. Veröffentlicht durch die Gesellschaft zur Förderung des Energiewirtschaftlichen Instituts an der Universität zu Köln e.V. Energiewirtschaftliches Institut an der Universität zu Köln (EWI).

Peek, M. and J. Grinschgl (2025). Einsatz der Netzreserve zur Strompreisstabilisierung: Auswirkungen auf das Stromversorgungssystem. Kurzstudie. enervis energy advisors GmbH. url: [https://enervis.de/wp-content/uploads/2025/07/MCS\\_Netzreserve\\_Kurzstudie\\_final.pdf](https://enervis.de/wp-content/uploads/2025/07/MCS_Netzreserve_Kurzstudie_final.pdf).

STEAG GmbH (2025). Bezahlbare Energiewende: Wie können Netzreserve-Kraftwerke einen Beitrag zur Dämpfung der Strompreise in Deutschland leisten? White Paper. Stellungnahme/Gutachten zur Ermöglichung eines wirtschaftlichen Betriebs von Netzreserve-Kraftwerken. Eingereicht am 20.03.2025 an den Deutschen Bundestag (Fraktionen/Gruppen und Mitglieder des Bundestages). Bezug auf §13b EnWG und §13i Abs. 3 Nr. 2 EnWG.

## Modeling approach:

Ambrosius, M., J. Egerer, V. Grimm, and A. H. van der Weijde (2020). "Uncertain bidding zone configurations: The role of expectations for transmission and generation capacity expansion." In: European Journal of Operational Research 285.1, pp. 343–359. doi: 10.1016/j.ejor.2020.01.024.

Egerer, J., V. Grimm, L. M. Lang, and U. Pfefferer (2025). "The coal phase out in Germany and Central Western Europe under new framework conditions." In: Energy Economics 151, p. 108886. doi: 10.1016/j.eneco.2025.108886.

Grimm, V., A. Martin, M. Schmidt, M. Weibelzahl, and G. Zöttl (2016). "Transmission and generation investment in electricity markets: The effects of market splitting and network fee regimes." In: European Journal of Operational Research 254.2, pp. 493–509. doi: 10.1016/j.ejor.2016.03.044.

## Reserve cost estimation on page 12:

Bundesnetzagentur (2025). Kraftwerksliste der Bundesnetzagentur: Stand 14.05.2025. url: <https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Versorgungssicherheit/Erzeugungskapazitaeten/Kraftwerksliste/start.html>.

Bundesnetzagentur and Bundeskartellamt (2025). Monitoringbericht 2025: Monitoringbericht gemäß § 63 Abs. 3 i. V. m. § 35 EnWG und § 48 Abs. 3 i. V. m. § 53 Abs. 3 GWB. url: <https://data.bundesnetzagentur.de/Bundesnetzagentur/SharedDocs/Mediathek/Monitoringberichte/MonitoringberichtEnergie2025.pdf>.

Smard (2025). Redispatch mit Reservekraftwerken: Mengen und Kosten für Redispatch mit Reservekraftwerken seit Juli 2022. url: <https://www.smard.de/page/home/topic-article/211816/213360/redispatch-mit-reservekraftwerken>.

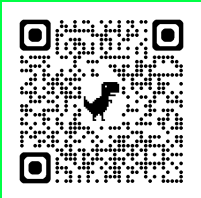


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